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Monsanto Research Corp, Dayton, OH

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Polybrominated Biphenyls

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16. ABSTRACT

The properties, uses, production processes and history of polybrominated biphenyls are dealt with in this report. The health and environmental hazards associated with polybrominated biphenyls are examined. Although no longer produced in large quantities, regulatory action is necessary for the clean-up of residues and for the control of any further production and use.

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Please change the following:

page iii, paragraph 2, line 3, from "acrylonitrile" to "polybrominated biphenyls."

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STATUS ASSESSMENT OF TOXIC CHEMICALS: POLYBROMINATED BIPHENYLS

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This report has been reviewed by the Industrial Environmental Research Laboratory - Cincinnati, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report contains a status assessment of the air emissions, water pollution, health effects, and environmental significance of acrylonitrile. This study was conducted to provide a better understanding of the distribution and characteristics of this pollutant. Further information on this subject may be obtained from the Organic Chemicals and Products Branch, Industrial Pollution Control Division.

Status assessment reports are used by IERL-Ci to communicate the readily available information on selected substances to government, industry, and persons having specific needs and interests. These reports are based primarily on data from open literature sources, including government reports. They are indicative rather than exhaustive.

David G. Stephan
Director
Industrial Environmental Research Laboratory
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ABSTRACT

Polybrominated biphenyls (PBB's), no longer produced for use in the United States, have been used commercially as flame retardant additives in synthetic fibers and molded thermoplastic parts.

Michigan Chemical Corp., located in St. Louis, Michigan, was the major U.S. manufacturer of PBB's, producing approximately 4,990 metric tons between 1970 and 1974. Also recently discontinuing PBB production, the White Chemical Corp. of Bayonne, New Jersey, produced approximately 454 metric tons of octabromo-biphenyl and decabromobiphenyl from 1970 to 1973. Nine companies have been suppliers of laboratory quantities of PBB's, each producing about 2.2 kg/yr.

The main sources of PBB's today appear to be the residues remaining in and around facilities which at one time manufactured, processed, or produced products using PBB's. Preliminary indications show that the level of PBB's in the water near a Cincinnati, Ohio plant which processed PBB's is from 1 ppm to 20 ppm. Concentrations as high as 0.15 g/m^3 have been detected in the Pine River at St. Louis even after shutdown of the PBB operation, possibly because of release of PBB's accumulated in discharge pipes or from contact with contaminated soils. Soils collected from bagging and loading areas at the Michigan plant were found to have 3,500 µg/kg and 2,500 µg/kg PBB, respectively.

Effects of PBB's on humans have not been fully documented. However, epidemiological studies are being conducted by the Michigan Department of Health and several other studies are underway to determine the health and ecological effects of PPB's.

The State of Michigan has been the focal point for responding to PBB contamination because of a 1973 incident in which PBB's were accidentally mixed into an animal feed supplement, resulting in widespread contamination of farm animals. EPA studies to assist the state are continuing. While residues about manufacturing and processing sites are the present major concern, a potential problem exists in the plastic and textile products still in use which contain the PBB's as flame retardants.

Regulatory action must be directed toward cleaning up residual PBB's in the environment from past emissions. Provided that PBB production continues, regulatory action to control emissions from production and transportation may be required. Locations of

manufacturer- and user-facilities should be determined. Information is needed to determine emission sources and population potentially exposed to PBB's from their manufacture, use, and disposal. Viable control technologies should also be identified.

This report was submitted in partial fulfillment of Contract 68-03-2550 by Monsanto Research Corporation under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period November 1, 1977 to December 31, 1977. The work was completed as of January 20, 1978.

CONTENTS

Foreword iii
Abstract iv
Abbreviations. viii
Conversion Factors and Metric Prefixes ix
Acknowledgements x

1. Introduction. 1
2. Summary 2
3. Source Description. 5
   Physical and chemical properties 5
   Production 6
   Production process 6
   Uses 7
4. Environmental Significance and Health Effects . . . 9
   Environmental significance 9
   Health effects 10
5. Control Technology. 13
6. Regulatory Action 14

References 16
Appendix 18

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ABBREVIATIONS

ABS	--acrylonitrile-butadiene-styrene
PPB's	--polybrominated biphenyls
ppb	--parts per billion
ppm	--parts per million
TSCA	--Toxic Substances Control Act

CONVERSION FACTORS AND METRIC PREFIXES[a]

CONVERSION FACTORS

To convert from	to	Multiply by
Degree Celsius (°C)	Degree Fahrenheit	$t_F^\circ = 1.8\ t_C^\circ + 32$
Kilogram (kg)	Pound-mass (pound-mass avoirdupois)	2.204
Meter^3 (m^3)	Gallon (U.S. liquid)	2.642×10^2
Metric ton	Pound-mass	2.205×10^3

METRIC PREFIXES

Prefix	Symbol	Multiplication factor	Example
Kilo	k	10^3	1 kg = 1×10^3 grams
Micro	μ	10^{-6}	1 μm = 1×10^{-6} meter

[a] Standard for Metric Practice. ANSI/ASTM Designation: E 380-76$^\epsilon$, IEEE Std 268-1976, American Society for Testing and Materials, Philadelphia, Pennsylvania, February 1976. 37 pp.

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SECTION 1

INTRODUCTION

Polybrominated biphenyls (PBB's), no longer produced for use in the United States, have been used commercially as flame retardant additives in synthetic fibers and molded thermoplastic parts. In 1973, 0.9 metric tons[a] to 1.8 metric tons of PBB's were accidentally mixed into an animal feed supplement and eventually fed to cattle in Michigan, causing widespread contamination of farm animals. Before the nature of the contamination was recognized, many of the contaminated animals had been slaughtered, marketed, and eaten, and milk of the contaminated animals was consumed. While no official standard for exposure level has been set, any exposure to PBB's is considered hazardous.

There is a need to define various sources from which PBB's may enter the environment, to establish consequent health and environmental health effects, and to examine possible control or cleanup measures and present regulatory actions. This report provides a brief overview describing these items with emphasis on PBB sources of emission and resulting environmental effects. Also discussed are PBB control techniques, and current regulatory actions.

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[a] 1 metric ton equals 10^6 grams; conversion factors and metric system prefixes are presented in the prefatory material.

SECTION 2

SUMMARY

PBB's may be represented by a biphenyl molecule with up to 10 substituted bromine atoms. PBB's are quite persistent in the environment and vaporize readily. They do not leach from thermoplastics in which they are incorporated.

Michigan Chemical Corp., located in St. Louis, Michigan, was the major U.S. manufacturer of PBB's, producing approximately 4,990 metric tons between 1970 and 1974. The White Chemical Corp., of Bayonne, New Jersey, produced approximately 454 metric tons of octabromobiphenyl and decabromobiphenyl from 1970 to 1973. PBB production at these locations has been discontinued. Nine companies have been suppliers of laboratory quantities of PBB's, each producing approximately 2.2 kg/yr.

Little information is available regarding PBB production methods. The process involves bromination of biphenyl in the presence of catalyst.

PBB's have been used commercially as flame retardant additives in synthetic fibers and molded thermoplastic parts. They have been incorporated into the plastic housings of many commercial products, such as typewriters, calculators, and microfilm readers, and industrial products, such as radio and television parts, thermostats, shavers, and handtools.

The main sources of PBB's today appear to be residues remaining in and around plants which at one time manufactured, processed, or produced products using PBB's. PBB emissions occurred at the St. Louis, Michigan, plant through contamination of the cooling water during the flaking operation. No other emission sources during manufacture have been identified.

Preliminary indications show that the level of PBB's in the water near an Ohio plant, which processed PBB's, is from 1 to 20 parts per million (ppm). Concentrations as high as 150 mg/m^3 (ppb) have been detected in the Pine River at St. Louis, Michigan, even after shutdown of the PBB operation. This may be due to delayed release of PBB's which were accumulated in discharge pipes or to leachate from contaminated soils. Soils collected from bagging and loading areas at the Michigan plant were found to have 3,500 µg/kg and 2,500 µg/kg PBB, respectively.

In 1973, 0.9 metric tons to 1.8 metric tons of PBB's were accidentally mixed into an animal feed supplement and fed to cattle in Michigan, resulting in widespread contamination of farm animals. Before the nature of the contamination was recognized, many of the contaminated animals had been slaughtered, marketed, and eaten. Milk of contaminated animals was also consumed. Approximately 10,000 persons have been identified in demographic studies as having been impacted by this incident.

Although the effect of PBB's on humans has not been fully documented, epidemiological studies are being conducted by the Michigan Department of Health and several other studies are underway to determine their health and ecological effects.

The State of Michigan has been the focal point for responding to PBB contamination. EPA studies to assist in assigning the most appropriate regulatory action are continuing. While residues about manufacturing and processing sites are the current major concern, a potential problem exists in the plastic and textile products still in use containing the PBB's as flame retardants.

It is possible that there are no significant emission sources at present. Since areas of concern include not only facilities producing PBB's for export, but also any plant that has ever used PBB's in production of thermoplastic resins or other products, regulatory action must be directed toward cleaning up residual PBB's in the environment from past emissions. Provided that PBB production continues, regulatory action to control emissions from production and transportation may be required.

Table 1 highlights information regarding PBB's. Based on the information presented in this report, the following items need to be considered for future studies:

- Current production statistics and locations should be identified for facilities manufacturing PBB's in the United States.

- Provided that PBB's are currently manufactured in the United States, production methods should be identified to determine emission sources.

- Population potentially exposed to PBB's from contamination by previous manufacturing facilities, disposal of PBB-containing products, and use of PBB-containing products should be investigated.

- Information is needed regarding control technology for disposal of environmental residues from previous PBB manufacture. Also, control technology should be identified for emissions from PBB manufacture provided that PBB's are currently produced in the U.S.

TABLE 1. POLYBROMINATED BIPHENYLS

Emission source	Extent of problem: Emission quantity	Extent of problem: Population exposed	Control method	Regulatory action
Production:				
Current	Does not appear to be a major source of emissions.	-	-	The U.S. Department of Agriculture, FDA, National Cancer Institute, EPA, Michigan State University, and the University of Michigan have conducted epidemiological, toxicological, analytical, and other projects to assess the extent of PBB contamination.
Previous	Residues remaining in and around plants which once manufactured, processed, or produced products using PBB's are the main sources. Up to 150 mg/m^3 have been detected in a river near a Michigan chemical plant, even after shutdown of PBB operation. Soil samples from the bagging area show a concentration of 3,500 µg/kg.	-	Stockpiles may be isolated or destroyed; however, environmental residues will be more difficult to control.	
Use:				
Accidents	Approximately 0.9 metric tons to 1.8 metric tons of PBB's were accidentally mixed in animal feed and fed to cattle in Michigan in 1973, resulting in widespread contamination of farm animals.	Approximately 10,000 persons have been impacted from the accidental use.	-	The FDA has set temporary action levels for PBB's in contaminated foods and feed.
Synthetic fibers	Fabrics treated with PBB are a potential hazard, but no data are available.	-	Replace with more expensive decabromodiphenyl ether or several other halogenated aliphatic compounds.	-
Molded thermoplastic	PBB's do not appear to leach from these products.	None.	None.	None.

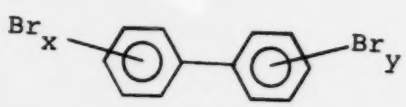
Note - Blanks indicate data not available.

SECTION 3

SOURCE DESCRIPTION

PHYSICAL AND CHEMICAL PROPERTIES

Polybrominated biphenyls (PBB's) may be represented by the following generalized structure, where Br_x and Br_y represent one to five substituted bromine atoms:



BP-6, the highly publicized PBB that was accidentally mixed with animal feed and fed to cattle in Michigan, is a mixture of polybrominated biphenyls with an average of six bromine atoms per molecule. BP-6 has a solubility of 11 parts per billion (ppb) in water at 25°C. It is a solid at room temperature and it decomposes at approximately 300°C to 400°C.

PBB's are quite persistent in the environment. PBB's were detected in soils from a field which had received manure from a PBB-contaminated herd 10 mo earlier. The flame retardant which contaminated the animals' feed contained two isomers of pentabromobiphenyl, four isomers of hexabromobiphenyl (one of which was the major component), and two isomers of heptabromobiphenyl. Only one pentabromobiphenyl showed any significant disappearance after 24 wk in the soil (1). As evidence of this persistence, PBB's are still found in Michigan food, although production was halted in 1974 (2).

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(1) Jacobs, L. W., S. Chou, and J. M. Tiedje. Fate of Poly brominated Biphenyls (PBB's) in Soils. Persistence and Plant Uptake. Journal of Agricultural Food Chemicals 24(6):1198-1201, 1976.

(2) Wheat, D., EPA Checking Area Plant Site for Possible Poisons in Soil. The Cincinnati Enquirer, Cincinnati, Ohio, August 4, 1977, p.1.

Although PBB's readily vaporize, they are not used as a liquid. They do not leach readily from the thermoplastics in which they are incorporated (3).

PRODUCTION

Michigan Chemical Corp., located in St. Louis, Michigan, was the major manufacturer of PBB's in the United States from 1970 through 1974. During these 5 yr, approximately 4,990 metric tons of PBB's were produced (4). PBB production by Michigan Chemical Corp. was discontinued on November 20, 1974 (personal communication with Frank Daniher, Director of Research, Michigan Chemical Corp., Ann Arbor, Michigan). The White Chemical Corp. of Bayonne, New Jersey, produced approximately 454 metric tons of the closely related compounds octabromobiphenyl and decabromobiphenyl from 1970 to 1973 (4). However, production by this company ceased several months ago (personal communication with Ms. Terry Simon, White Chemical Corp., Bayonne, New Jersey). In addition, nine companies have been suppliers of laboratory quantities of PBB's each producing approximately 2.2 kg/yr (4). Hexcel Corp., located in Lodi, New Jersey, has previously produced and exported PBB's; however, the status of current production is unknown. There is no indication that this material is imported. A summary of telephone conversations with industry representatives regarding PBB production is presented in the Appendix.

PRODUCTION PROCESS

Little information is available regarding PBB production methods. The process involves bromination of biphenyl in the presence of catalyst. While there is a slight similarity to the manufacturing process for polychlorinated biphenyls, the two methods are essentially different.

Ethyl Corp. reported in 1973 that mixtures of PBB's with an average of less than or equal to 10 bromine atoms were prepared by brominating biphenyl with dibromomethane in the presence of

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(3) Hesse, J. L., Water Pollution Aspects of Polybrominated Biphenyl Production: Results of Surveys in the Pine River in the Vicinity of St. Louis, Michigan. In: Proceedings of the Second National Conference on Complete Water Reuse, Water's Interface with Energy, Air and Solids. The American Institute of Chemical Engineers and the U.S. Environmental Protection Agency Technology Transfer, Chicago, Illinois, May 4-8, 1975.

(4) Summary Characterizations of Selected Chemicals of Near-Term Interest. EPA-560/4-76-004 (PB 255 817), U.S. Environmental Protection Agency, Washington, D.C., April 1976. 50 pp.

aluminum chloride or aluminum bromide at 25°C to 95°C (5). Whether this method is the commercially preferred technique is unclear.

USES

PBB's have been used commercially as flame retardant additives in synthetic fibers and molded thermoplastic parts (4). Used by manufacturers in the plastic, resin, and synthetic fiber industry, they are added to polymers (thermoplastic resins) in mixing and blending steps after polymerization (6). PBB's may be added to fiber polymers during spinning and finishing operations (7). PBB's have been incorporated into the plastic housings of many commercial products, such as typewriters, calculators, and microfilm readers; and consumer products, such as radio and television parts, thermostats, shavers and handtools (4).

Octabromobiphenyl, produced by Great Lakes Chemical Corp., was used as a flame retardant in acrylonitrile-butadiene-styrene (ABS) and polyolefin resins. PBB's manufactured by White Chemical Corp. were sold to manufacturers of polycarbonates, polyesters, polyolefins, and polystyrene (8).

Manufacturing facilities using PBB's in polymer products are numerous. Producers of some fibers and resins number in the hundreds and are catalogued in the available literature by production location and products (6, 7).

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(5) Mitchell, L. C. Catalytic Production of Polybrominated Biphenyls, U.S. Patent 3,763,623 (to Ethyl Corporation), October 2, 1973.

(6) Wilkins, G. E. Industrial Process Profiles for Environmental Use, Chapter 10. Plastics and Resins Industry, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (Submitted to the EPA by Radian Corporation, February, 1977.)

(7) Parr, J. L. Industrial Process Profiles for Environmental Use. Chapter 11, The Synthetic Fiber Industry, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. (Submitted to the EPA by Radian Corporation, February, 1977.)

(8) Modern Plastics Encyclopedia.

Table 2 lists end uses of BP-6 manufactured by Michigan Chemical Corp. (3).

TABLE 2. INDUSTRIAL USES OF FIREMASTER BP-6[a] (3)

Industry type	Products	Percent of total production
Business machines and industrial equipment	Typewriter, calculator, and microfilm reader housings.	48
Electrical	Radio, and TV parts, thermostats, and shaver and hand tool housings.	35
Fabricated products	Projector housings and movie equipment cases.	12
Transportation	Miscellaneous small automotive parts; i.e., electrical wire connectors and speaker grills.	1
Miscellaneous	Components for industrial equipment.	4

[a]As presented by A. Fred Kerst, Vice President of Research and Development, Michigan Chemical Corp., to the Michigan Environmental Review Board, September 23, 1974.

Among the substitutes for PBB's are the more expensive decabromobiphenyl oxide and several halogenated aliphatic compounds, but the environmental significance of these substitutes is unknown (4).

No specific information has been obtained regarding transportation of PBB's.

SECTION 4

ENVIRONMENTAL SIGNIFICANCE AND HEALTH EFFECTS

ENVIRONMENTAL SIGNIFICANCE

Sources

The main sources of PBB's today appear to be residues remaining in and around plants which at one time manufactured, processed, or produced products using PBB's. In addition to the manufacture sites described in Section 3, contamination was recently found near industrial plants on Staten Island, New York, and in New Jersey. The U.S. Environmental Protection Agency (EPA) is currently examining a plant in Cincinnati, Ohio, which processed PBB's in 1972, along with seven other suspected plants (2).

PBB emissions occurred at the Michigan Chemical Corp. plant through contamination of the cooling water during the flaking operation. No other sources of emissions during manufacture have been identified (3).

PBB powder can contaminate the soil in bagging and loading operations and, from these, be leached to the waterways.

Environmental Levels

Preliminary indications show that the level of PBB's in the water near the Cincinnati plant under investigation is from 1 ppm to 20 ppm (2).

Monitoring in the Pine River near the St. Louis, Michigan, facility where polybrominated biphenyls were produced indicated that PBB levels diminished from 3.2 parts per billion (ppb) in the ambient stream near the effluent discharge to 0.01 ppb 13 km downstream. Fish obtained in this 13 km stretch contained levels of 0.09 ppm to 1.33 ppm. Near the New Jersey plants, a level of 100 ppm was found in a sediment sample, 10 ppb to 60 ppb in receiving water, and 1 ppm to 2.7 ppm in soils near the two producing plants. Land-based plant samples showed 0.3 ppm to 10 ppm, and aquatic specimens had 0.3 ppm to 1 ppm. Three of nine human hair samples contained 0.03 ppm, 1 ppm, and 2 ppm.

In September 1974, an estimated 0.11 kg/day PBB's were discharged to the Pine River at St. Louis, Michigan (3). Contamination was found as far as 13 km below the city.

Concentrations as high as 0.15 g/m^3 have been detected in the Pine River at St. Louis even after shutdown of the PBB operation, possibly because of release of PBB's accumulated in discharge pipes or from contact with contaminated soils. Soils collected from bagging and loading areas at the Michigan Chemical plant were found to have 3,500 µg/kg and 2,500 µg/kg PBB, respectively.

Population at Risk

Assuming that Hexcel Corp. is still producing PBB's, an area with a population of about 1,300,000 persons could be exposed. Approximately 10,000 individuals have been identified in demographic studies as having been impacted by the Michigan feed contamination incident (9).

Potential population risks exist in the disposal of products such as business machines, industrial equipment, and fabricated parts whose plastic components may contain PBB's as fire retardants. Fumes may be generated inadvertently in fires or from burning in dumps.

At St. Louis, Michigan, and other locations, such as Cincinnati, Ohio, where handling of the material has ceased, there is possible inclusion of PBB's into the water supply, contamination of fish and other wildlife, and danger to persons working in the plants.

The risk to persons using fabrics treated with PBB's has not been investigated.

HEALTH EFFECTS

Effects on Humans

Effects of PBB's on humans have not been fully documented. However, epidemiological studies are being conducted by the Michigan Department of Health and several other studies are underway to determine the health and ecological effects of PBB's (9). A paper on the epidemiological investigation of human exposure to PBB's was presented at the Ninth Annual Conference on Trace Substances in Environmental Health, University of Missouri, June 10, 1975. The National Institute of Environmental Health Sciences confirms earlier reports that farmers

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(9) Identification of Selected Federal Activities Directed to Chemicals of Near-Term Concern. EPA-560/4-76-006 (PB 257 494), U.S. Environmental Protection Agency, Washington, D.C., July 1976. 36 pp.

exposed to PBB's in Michigan in 1973 are more susceptible to disease (10).

Following disclosure in May 1974 that PBB-contamination of cattle feed had occurred, some 90% of quarantined farms were contacted by the Michigan Department of Public Health. Initially, it appeared that over 250 persons had been exposed and that 500 others had used products from the farms. Eventually, a sample of 165 exposed persons (quarantined farms) and 133 nonexposed (non-quarantined farms) was selected to permit correlation of PBB levels in the body with illness. Medical history interviews, physical examinations, and the collection of blood specimens were begun in October 1974. The object was to assess short-term effects of PBB on health. Positive blood values for PBB were found among 74 adults and 30 children on non-quarantined farms (97% below 0.019 ppm), whereas on quarantined farms only 52% of 82 adults and 29% of 28 children showed levels below 0.019 ppm. There were 6 adults and 7 children with levels between 0.5 and 2.26 ppm. There was no significant difference between the frequencies of the conditions and complaints of the quarantined and nonquarantined groups. It was then established that the complaints of 17 adults with the highest PBB blood levels (0.1-2.26 ppm) were no more frequent than those of the remainder of the study group, regardless of whether they were in the quarantined or nonquarantined groups. In terms of family clusters, an interesting finding was that some of those on the nonquarantined farms had had exposure to PPB. The results of physical examinations and clinical laboratory tests failed to establish any effect of PBB exposure. A further study of possible long-term effects is to be carried out by the Michigan Health Department (11).

Any human exposure to PBB is considered hazardous; however, no official standard for exposure level has been set (2).

Effects on Animals

PBB's accumulate in fish at 10,000 times to 50,000 times ambient levels (3). Large amounts of PBB's are also accumulated in duck tissues.

About 400 cows given contaminated feed for 16 days exhibited anorexia, decreased milk production, increased frequency of urination, some lameness, abnormal hoof growth, and shrinking of the udder. Later signs of toxic effects included bloody blebs,

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(10) Toxic Materials News. L. S. Stern, ed. Business Publishers, Inc., Silver Springs, Maryland. July 20, 1977.

(11) Kay, K. Polybrominated Biphenyls (PBB) Environmental Contamination in Michigan, 1973-1976. Environmental Research (13)1:74-93, 1977.

malformed or dead fetuses, abcesses, weight loss, and high susceptibility to stress. Nonlactating cows died within six months, while the lactating cows survived and gradually improved. Massive liver abcesses were found in the dead animals (4). More information on the pathology of PBB's in cattle can be found in the Journal of the American Veterinarians' Medical Association and the Journal of the Dairy Society (12, 13, 14).

PBB's are immuno-suppressant agents in guinea pigs. Neoplastic liver nodules have been noted in rats exposed to PBB's. University of Michigan Medical School Studies have shown adverse effects of PBB's on the kidney, liver, and thyroid of rats and mice (4).

Short-term exposure to PBB's can interfere with reproduction and liver functions, promote nervous disorders, and react as a teratogenic agent in tissues of rats, mice and cattle. PBB's have produced pathological changes in the livers of rats, mice, guinea pigs, cows, and rabbits (4).

After PBB was mistakenly substituted in a cattle feed in Michigan in 1973, animal symptoms included brain weight loss and roughening, abnormal hoof growth, losses in weight, and milk production, excessive abortions and still-births, loss of vitality in adults and offspring, and in some cases death (3).

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(12) Moorhead, P. D., L. B. Willett, C. J. Brumm, and H. D. Mercer. Pathology of Experimentally Induced Polybrominated Biphenyl Toxicosis in Pregnant Heifers. Journal of the American Veterinarians' Medical Association, 170(3):307-313, 1977.

(13) Fries, G. F., and G. S. Morrow. Excretion of Polybrominated Biphenyls into the Milk Cows. Journal of the Dairy Society, 58(6):947-951, 1975.

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SECTION 5

CONTROL TECHNOLOGY

Production of PBB's does not appear to be a source of emissions at present. At the Michigan chemical plant in 1972 before hazards were known, emissions of BP-6 in the production area were caused by contamination of cooling water during the flaking operation. Sampling of the outfall indicated levels of 0.98 mg/m^3 to 5.03 mg/m^3. To solve the problem, additional shielding was added to the flaker, and a brine chiller was added to allow recirculation instead of disposal of the flaker cooling water. Condenser cooling water was repiped to another outfall. The first outfall was abandoned. In 1974, the highest concentration detected at the second outfall was 0.11 mg/m^3 (3).

Current potential emission sources of this chemical include possible stockpiles at producer and user locations, residues in the ambient and natural environment, and possible emissions from use and disposal of products containing PBB's.

Stockpiles can be controlled by destruction or isolation of the chemical. Since PBB's are similar to, but less stable than polychlorinated biphenyls (PCB's), control technologies used for PCB control and destruction such as high temperature incineration, should be applicable to PBB's. Environmental residues will be more difficult to control.

SECTION 6

REGULATORY ACTION

The State of Michigan has been the focal point for responding to the contamination incident. In addition, the U.S. Department of Agriculture, the Food and Drug Administration, the National Cancer Institute, Communicable Disease Center, EPA, Michigan State University, and the University of Michigan have conducted wide array of epidemiological, toxicological, analytical, and related projects to clarify the effects of the chemical on humans and animals and to assess the extent of contamination. The Toxicology Coordinating Committee of the U.S. Department of Health, Education, and Welfare is preparing a synthesis of available health effects information. EPA provides assistance in environmental monitoring.

The Food and Drug Administration has set temporary action levels for polybrominated biphenyls in contaminated foods and in animal feed. The State of Michigan has issued warnings to sport fishermen along the Pine River.

The Environmental Protection Agency has set up a work group to write regulations on PBB's. The group has released an informal draft schedule in which a draft of the regulation would go to Assistant Administrator for Toxic Substances, Steven Jellinek, on March 1, 1978. About one month later, draft would go to the EPA Steering Committee, and would be submitted for Administrative signature at the end of April. On May 1, the rules would be formally proposed; a hearing would follow in July, and final rules would be announced in September 1978. The group is seeking comments on the following issues: 1) Should PBB's be used in any form or should specific uses of PBB's be restricted? 2) If PBB's are not allowed to be used in the U.S., should their manufacture be allowed for export? 3) What is the appropriate form of control? Should control be a regulation restricting production, end uses, etc.? 4) What will be the impact on existing state laws? 5) What type of controls, if any, should be placed on articles containing PBB's? and 6) What type of controls, if any, should be placed on disposal of PBB's (15)?

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(15) Toxic Materials News. L. S. Stern, ed. Business Publishers, Inc., Silver Springs, Maryland. October 19, 1977.

Michigan's Governor William Milliken has requested that the Public Health Department accelerate testing of nonfarm residents for the chemical. That department is currently developing a scheme to accomplish that additional testing; alternatives under consideration include setting up clinic programs or making the testing service available through private physicians. Health department representatives say, however, that their labs are at peak capacity now, and more funding to allow the contracting of commercial labs will be needed (16).

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(16) Toxic Materials News. L. S. Stern, ed. Business Publishers, Inc., Silver Springs, Maryland. August 17, 1977.

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APPENDIX

TELEPHONE CONTACTS BETWEEN INDUSTRY AND RADIAN CORPORATION

Industry Contacts	Telephone Number
Dr. Frank Daniher Director of Research Michigan Chemical Corp. Ann Arbor, MI	313-994-8000

Michigan Chemical Corp. has not produced PBB's since November 20, 1974.

Ms. Terry Simon White Chemical Corp. Bayonne, NJ	212-421-7000

White Chemical Corp. has manufactured no PBB's "since several months ago."

Dr. Robert Ortlep General Manager Fine Organics, Inc. Hexcel Corp. Lodi, NJ	201-472-6800

A statement has already been issued to the government. Any further inquiries should be directed in writing to Laverne Mafinski.

Bill Blake Great Lakes Chemical West Lafayette, IN	317-463-2511

Great Lakes Chemical has never produced PBB's.

Jack Eadie Dow Chemical Midland, MI	517-636-1000

They have never manufactured any PBB's or products derived from it.

Velsicol Chemical Corp.
Chicago, IL

312-670-4500

Check with Howard Waster for a firm answer. One person who couldn't be quoted said PBB's had not been produced since November 1975. (Velsicol merged with Michigan Chemical early this year.)

Fred Fields
Ethyl Corp.
Baton Rouge, LA

504-388-7518

Ethyl Corp. has never manufactured PBB's.